FIG. 1

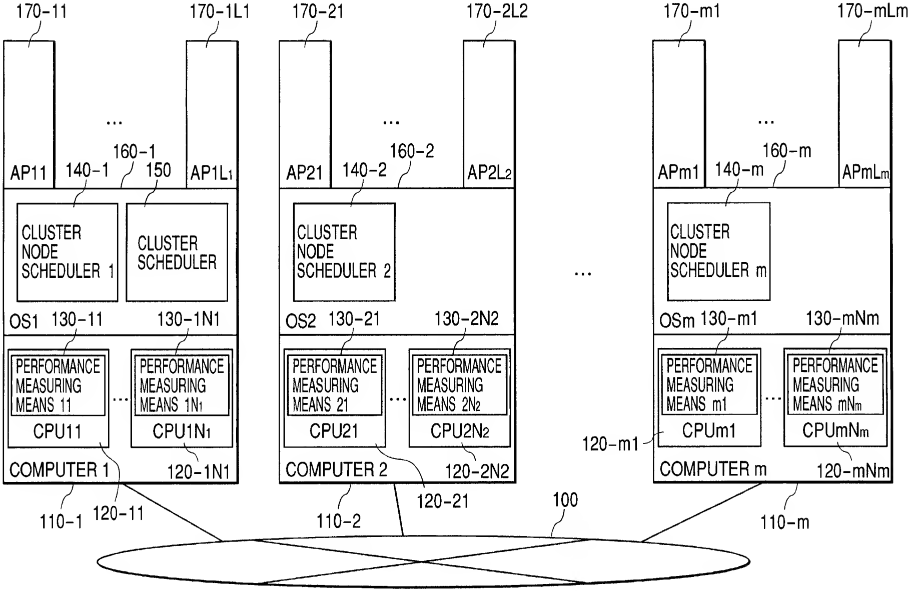

170-11
170-1L1
170-21
170-2L2
170-m1
170-mLm
AP11
140-1
160-1
150
AP1L1
AP21
140-2
160-2
AP2L2
APm1
140-m
160-m
APmLm
CLUSTER NODE SCHEDULER 1
CLUSTER SCHEDULER
CLUSTER NODE SCHEDULER 2
CLUSTER NODE SCHEDULER m
OS1
130-11
130-1N1
OS2
130-21
130-2N2
OSm
130-m1
130-mNm
PERFORMANCE MEASURING MEANS 11
CPU11
PERFORMANCE MEASURING MEANS 1N1
CPU1N1
PERFORMANCE MEASURING MEANS 21
CPU21
PERFORMANCE MEASURING MEANS 2N2
CPU2N2
PERFORMANCE MEASURING MEANS m1
CPUm1
PERFORMANCE MEASURING MEANS mNm
CPUmNm
COMPUTER 1
120-1N1
COMPUTER 2
120-2N2
120-m1
COMPUTER m
120-mNm
110-1
120-11
110-2
120-21
100
110-m

FIG. 2

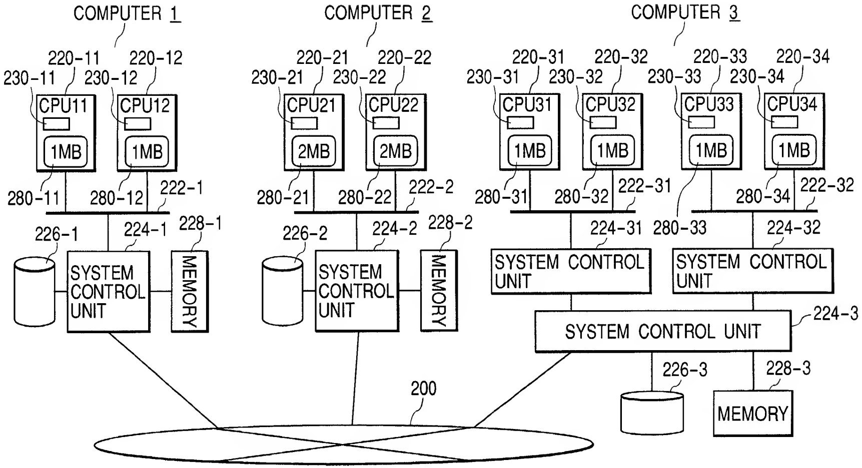

COMPUTER 1
COMPUTER 2
COMPUTER 3
220-11
220-12
230-11
230-12
CPU11
CPU12
1MB
1MB
280-11
280-12
222-1
226-1
224-1
228-1
SYSTEM CONTROL UNIT
MEMORY
220-21
220-22
230-21
230-22
CPU21
CPU22
2MB
2MB
280-21
280-22
222-2
226-2
224-2
228-2
SYSTEM CONTROL UNIT
MEMORY
220-31
220-32
220-33
220-34
230-31
230-32
230-33
230-34
CPU31
CPU32
CPU33
CPU34
1MB
1MB
1MB
1MB
280-31
280-32
280-33
280-34
222-31
222-32
224-31
224-32
SYSTEM CONTROL UNIT
SYSTEM CONTROL UNIT
224-3
SYSTEM CONTROL UNIT
226-3
228-3
MEMORY
200

FIG. 3

CLUSTER NODE	NODE	CPU	CACHE CAPACITY	MEMORY LATENCY
1	1	1	1MB	200ns
1	1	2	1MB	200ns
2	1	1	2MB	200ns
2	1	2	2MB	400ns
3	1	1	1MB	400ns
3	1	2	1MB	400ns
3	2	3	1MB	400ns
3	2	4	1MB	400ns

FIG. 4

CLUSTER NODE	NODE	NODE THROUGHPUT
1	1	1GB/s
2	1	1GB/s
3	1	0.5GB/s
3	2	0.5GB/s

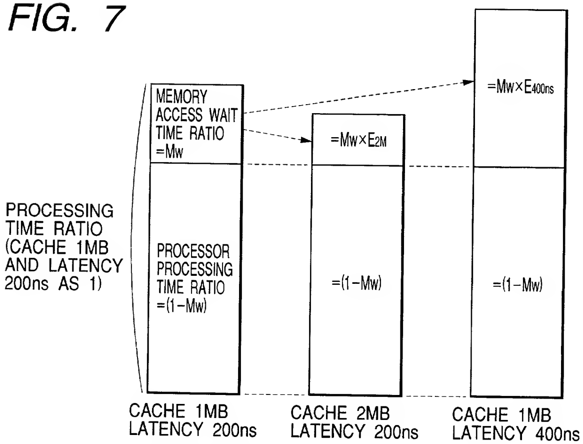
FIG. 5

CLUSTER NODE	CLUSTER NODE THROUGHPUT
1	1GB/s
2	1GB/s
3	1GB/s

FIG. 6

AP	CPU	PROCESSOR OPERATION CHARACTERISTICS
AP1	(1,1,1)	→ NONE
AP2	(1,1,2)	→ NONE
AP3	(2,1,1)	→ NONE
AP4	(2,1,2)	→ NONE
AP5	(3,1,1)	→ NONE
AP6	(3,1,2)	→ NONE
AP7	(3,2,3)	→ NONE
AP8	(3,2,4)	→ NONE

FIG. 7



M_W : MEMORY ACCESS WAIT TIME RATIO FOR CACHE 1MB AND LATENCY 200ns (%)
T : MEMORY ACCESS SIZE FOR CACHE 1MB AND LATENCY 200ns (GB/s)
E_{2M} : LATENCY/THROUGHPUT RATIO WHEN UPGRADING THE CACHE SIZE FROM 1MB TO 2MB (=2/3)
E_{400ns} : LATENCY RATIO WHEN DOWNGRADING THE MEMORY ACCESS LATENCY FROM 200ns TO 400ns

FIG. 8

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AP	CPU
AP1	(1,1,1)
AP2	(1,1,2)
AP3	(2,1,1)
AP4	(2,1,2)
AP5	(3,1,1)
AP6	(3,1,2)
AP7	(3,2,3)
AP8	(3,2,4)

PROCESSOR OPERATION CHARACTERISTICS

CPU	MEMORY WAIT RATIO	THROUGHPUT
(1,1,1)	5%	0.42GB/s
(1,1,2)	5%	0.42GB/s
(2,1,1)	22%	0.44GB/s
(2,1,2)	9%	0.10GB/s
(3,1,1)	53%	0.51GB/s
(3,1,2)	33%	0.25GB/s
(3,2,3)	10%	0.10GB/s
(3,2,4)	31%	0.30GB/s

FIG. 9

PROCESS NAME	PROCESSOR ASSIGNMENT	PROCESSOR WITH CACHE 1MB AND LATENCY 200ns			PROCESSOR WITH CACHE 2MB AND LATENCY 200ns			PROCESSOR WITH CACHE 1MB AND LATENCY 400ns		
		Mw'	T'	PERFORMANCE RATIO	Mw'	T'	PERFORMANCE RATIO	Mw'	T'	PERFORMANCE RATIO
AP1	(3,1,1)	5%	0.42GB/s	1.00	3%	0.28GB/s	1.02	10%	0.40GB/s	0.95
AP2	(3,2,4)	5%	0.42GB/s	1.00	3%	0.28GB/s	1.02	10%	0.40GB/s	0.95
AP3	(2,1,1)	30%	0.60GB/s	1.00	22%	0.44GB/s	1.11	46%	0.46GB/s	0.77
AP4	(3,1,2)	13%	0.15GB/s	1.00	9%	0.10GB/s	1.05	23%	0.13GB/s	0.88
AP5	(2,1,2)	36%	0.69GB/s	1.00	27%	0.52GB/s	1.14	53%	0.51GB/s	0.74
AP6	(1,1,1)	20%	0.30GB/s	1.00	14%	0.21GB/s	1.07	33%	0.25GB/s	0.83
AP7	(3,2,3)	5%	0.11GB/s	1.00	3%	0.07GB/s	1.02	10%	0.10GB/s	0.95
AP8	(1,1,2)	18%	0.35GB/s	1.00	13%	0.25GB/s	1.06	31%	0.30GB/s	0.85

TOTAL OF PERFORMANCE RATIOS=7.53

FIG. 10

	HIGH MEMORY THROUGHPUT REQUIRED	LOW MEMORY THROUGHPUT REQUIRED
MEMORY ACCESS WAIT TIME RATIO IS HIGH	① USE OF CPU WITH LARGE CAPACITY CACHE ② USE OF CPU WITH SMALL MEMORY LATENCY ③ USE OF PROCESSOR/COMPUTER WITH HIGH MEMORY THROUGHPUT PER CPU/NODE/CLUSTER NODE	① USE OF CPU WITH LARGE CAPACITY CACHE ② USE OF CPU WITH SMALL MEMORY LATENCY
MEMORY ACCESS WAIT TIME RATIO IS LOW	① USE OF CPU WITH LARGE CAPACITY CACHE ② USE OF PROCESSOR/COMPUTER WITH HIGH MEMORY THROUGHPUT PER CPU/NODE/CLUSTER NODE	—

FIG. 11

PROCESS NAME	PROCESSOR ASSIGNMENT	PROCESSOR WITH CACHE 1MB AND LATENCY 200ns			PROCESSOR WITH CACHE 2MB AND LATENCY 200ns			PROCESSOR WITH CACHE 1MB AND LATENCY 400ns		
		Mw'	T'	PERFORMANCE RATIO	Mw'	T'	PERFORMANCE RATIO	Mw'	T'	PERFORMANCE RATIO
AP1	(3,1,1)	5%	0.42GB/s	1.00	3%	0.28GB/s	1.02	10%	0.40GB/s	0.95
AP2	(3,2,4)	5%	0.42GB/s	1.00	3%	0.28GB/s	1.02	10%	0.40GB/s	0.95
AP3	(2,1,1)	30%	0.60GB/s	1.00	22%	0.44GB/s	1.11	46%	0.46GB/s	0.77
AP4	(3,1,2)	13%	0.15GB/s	1.00	9%	0.10GB/s	1.05	23%	0.13GB/s	0.88
AP5	(2,1,2)	36%	0.69GB/s	1.00	27%	0.52GB/s	1.14	53%	0.51GB/s	0.74
AP6	(1,1,1)	20%	0.30GB/s	1.00	14%	0.21GB/s	1.07	33%	0.25GB/s	0.83
AP7	(3,2,3)	5%	0.11GB/s	1.00	3%	0.07GB/s	1.02	10%	0.10GB/s	0.95
AP8	(1,1,2)	18%	0.35GB/s	1.00	13%	0.25GB/s	1.06	31%	0.30GB/s	0.85

TOTAL OF PAFORMANCE RATIOS=7.99

FIG. 12

AP	CPU
AP1	(3,1,1)
AP2	(3,2,3)
AP3	(2,1,1)
AP4	(3,1,2)
AP5	(2,1,2)
AP6	(1,1,1)
AP7	(3,2,4)
AP8	(1,1,2)

PROCESSOR OPERATION CHARACTERISTICS

CPU	MEMORY WAIT RATIO	THROUGHPUT
(3,1,1)	10%	0.40GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(1,1,1)	5%	0.42GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(3,2,3)	10%	0.40GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(1,1,2)	5%	0.42GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(2,1,1)	22%	0.44GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(3,1,2)	23%	0.13GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(2,1,2)	9%	0.10GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(2,1,2)	27%	0.52GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(3,1,1)	53%	0.51GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(1,1,1)	20%	0.30GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(3,1,2)	33%	0.25GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(3,2,4)	10%	0.10GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(3,2,3)	10%	0.10GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(1,1,2)	18%	0.35GB/s

CPU	MEMORY WAIT RATIO	THROUGHPUT
(3,2,4)	31%	0.30GB/s

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FIG. 13

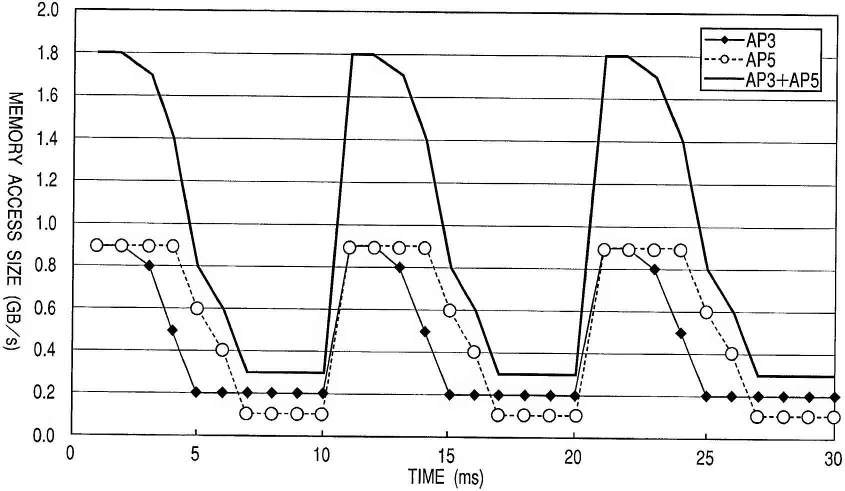
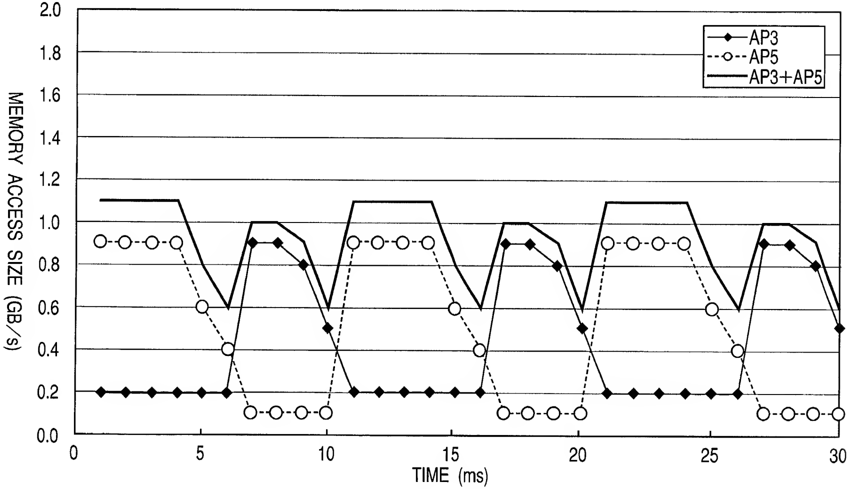
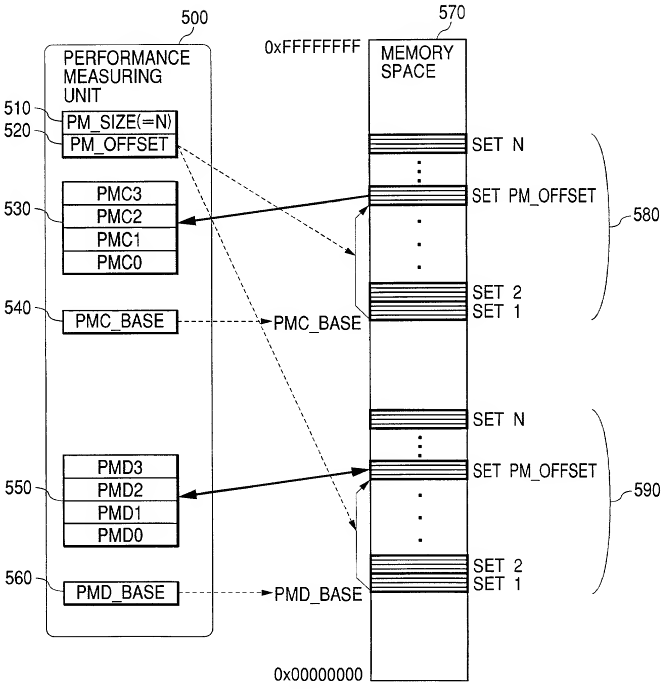

MEMORY ACCESS SIZE IN SIMULTANEOUS PROCESS SWITCHING

FIG. 14



MEMORY ACCESS SIZE IN ASYNCHRONOUS PROCESS SWITCHING

FIG. 15


500
PERFORMANCE MEASURING UNIT
510
PM_SIZE(=N)
520
PM_OFFSET
530
PMC3
PMC2
PMC1
PMC0
540
PMC_BASE
550
PMD3
PMD2
PMD1
PMD0
560
PMD_BASE
570
0xFFFFFFFF
MEMORY SPACE
SET N
SET PM_OFFSET
580
SET 2
SET 1
PMC_BASE
SET N
SET PM_OFFSET
590
SET 2
SET 1
PMD_BASE
0x00000000